

REMARKS

Claims 16-26 are now active in the application.

As noted in the response to Non-Final Office Action filed December 22, 2006 (incorporated herein by reference), the present application relates to a method of operating a plating bath such that the number of voids in the plated metal is minimized. The method involves first plating a metal on a substrate in a plating bath containing an accelerator. Then an accelerator breakdown product concentration and remaining accelerator concentration is measured along with the number of voids in the plated metal. This process is repeated and the relative concentration of accelerator breakdown product to accelerator concentration (VFM ratio) is then determined as a function of the number of voids in the plated metal.

The plating bath is then operated at a VFM ratio below the highest VFM ratio at which no voids are observed. The results of this process are illustrated in Fig. 4 of the specification where the number of voids as a function of the VFM ratio is plotted. The method provides for a convenient method of operating a plating bath while minimizing the number of metal voids. Applicants have found that the relative concentration of accelerator breakdown product to accelerator determines the number of metal voids in a plating process. This process provides for an improvement over traditional methods which seek to improve plating operations by controlling a single variable which is typically the absolute concentration of starting materials or by-product contaminants in the plating bath. None of the cited references teach or suggest this relativistic approach to operating a plating bath.

The Office has rejected claims 16-20 and 24-26 under 35 U.S.C. §103(a) over the combination of Seita et al. (U.S. Patent No. 6,881,319), Blanchier et al. (U.S. Patent No. 6,569,307), Kopp (U.S. Patent No. 6,083,374) and Sun et al. (U.S. Publication No. 2002/0125142). In addition, the Office has rejected claim 21 under 35 U.S.C. §103(a) over the combination of Seita, Blanchier, Kopp, Sun and Skogg (Fundamentals of analytical chemistry) and has rejected claims 22 and 23 under 35 U.S.C. §103(a) over the combination of Seita, Blanchier, Kopp, Sun and Talasek (U.S. Publication No. 2004/0108213).

Seita describes a method for controlling an electrolytic copper plating solution. The method involves addition of a thiol-reactive compound to the plating solution to maintain the decomposition products of a specific sulfur-containing compound which is added for the purpose of increasing the deposition rate in the vicinity of the bottom of a micro via whole (column 2, lines 15-56). The method includes maintaining a specific maximum allowable concentration for the decomposition product (0.15 $\mu\text{mol/L}$) and adding thiol-reactive compound (1×10^{-4} to 1×10^{-1} mol/L) to maintain the bath below the maximum allowable decomposition product concentration (column 5, lines 64-67 and column 7, lines 4-15). Overall, Seita describes controlling the decomposition product to an absolute concentration using a chemical additive (a thiol-reactive compound).

The Office has stated that the determination of the maximum allowable concentration for the decomposition product corresponds to the “void formation marker, VFM” recited in claim 16. Applicants agree that the VFM is a measurement of at least one accelerator breakdown product and that Seita describes the measurement of the decomposition product of a specific sulfur-containing compound. However, the Office has not distinguished between a VFM value and the VFM ratio. The VFM ratio is the concentration of the VFM divided by the concentration of the accelerator. The claimed method distinguishes over the references by use of the VFM ratio to control the plating bath operation.

As noted above, the determination of the VMF ratio and the use of this ratio to operate a plating bath is not taught or suggested by the cited references. Specifically, the Office has noted on page 3 of the Office Action that Seita and Blanchier describe monitoring only the breakdown concentration not both the breakdown concentration and the original concentration of the plating bath component. Accordingly, the combination of these references does not teach or suggest all the recitations of the claimed method (i.e. using the VMF ratio to control plating bath operation).

The Office has noted on page 4 of the Office Action (Item 12) that the VFM ratio is not taught or suggested by the cited references. However, the Office concludes that the determination of the claimed VFM value and the claimed measuring of the bath concentration of the at least an accelerator is taught by the combination of the references. The Office Action

continues by stating that “[a] mathematic calculation (determining) is not a patentable designation and therefore the prior art inherently teaches such determination steps.” Applicants submit that this analysis misses the point that the calculated VMF ratio is used to control plating bath operation and this method step is not taught or suggested by the cited references. Applicants are not claiming a mathematical calculation, but the use of that calculated number in a useful method step. Simply knowing the VMF number and the acceleration component concentration (C) does not teach or suggest using the ratio of these numbers to control a process. The relationship $VFM\ ratio = VMF/C$ may exist in the reference plating bath, but controlling the bath to a given VMF or a given C is not the same as controlling to a given VMF ratio. The cited references do not teach or suggest utilization of this relationship in a process and this distinction alone renders the claimed method non-obvious over the cited references. Applicants have found that this ratio provides a good control of plating bath operation. The cited references describe using a single absolute value such as the concentration of the decomposition products to control plating bath operations not the ratio of two plating bath constituents.

The Office Action also notes that the combination of Seita, Blanchier and, Kopp and Sun describe maintaining the breakdown products concentration below a fixed VFM concentration and the concentration of substances in a plating bath at a constant value. Applicants note that the claimed method does not require this VFM and the accelerator concentration to be individually fixed or constant. The VFM ratio is a relative number that does not require these two concentrations to individually be constant or fixed. The two concentrations may vary individually with the ratio of these two values (VFM ratio) being used to control operations. Again, this is a distinction of the claimed method over the combination of the cited references. Accordingly, the claimed method would not have been obvious over the combination of these cited references. Accordingly, Applicants respectfully request that the Office withdraw the rejections of claims 16-20 and 24-26 under 35 U.S.C. §103(a) over Seita, Blanchier, Kopp and Sun.

In addition, Applicants are unsure as to how the Office is proposing to modify Seita. As noted above, Seita requires adding a thiol-reactive compound to neutralize a deleterious decomposition product of a sulfur-containing compound. Elimination of this required step

would render the described method in Seita unsuitable for its intended purpose. Why would one skilled in the art be motivated to eliminate this required step? If this required step were maintained, Applicants are unsure as to how the proposed method would operate. Would there be an expectation of success in combining the method in Seita with the other cited methods? How would such a process successfully operate? Since the proposed modification would either render Seita unsuitable for its intended purpose or give a process with an unknown expectation of success, the claimed process would not be obvious over Seita in combination with Blanchier, Kopp and Sun.

Finally, Applicants submit that references Skoog and Talasek do not make up for the deficiencies of Seita, Blanchier, Kopp and Sun. Accordingly, Applicants respectfully request that the Examiner withdraw the rejection of claims 21-23 under 35 U.S.C. §103(a).

In light of the remarks above, Applicants submit the application is in condition for allowance. Favorable reconsideration is respectfully requested.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 50-0510, under Order No. 20140-00302-US from which the undersigned is authorized to draw.

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Respectfully submitted,
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